Transport Properties of Granular Metals

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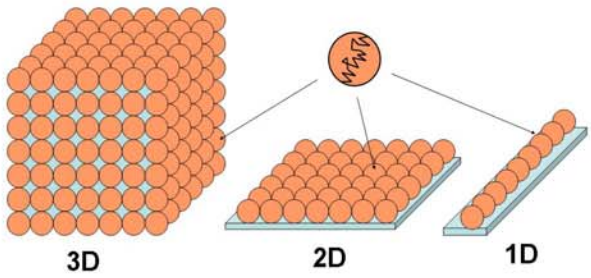
Motivation:

Creation of new artificial materials with programmable electronic properties.

Open questions:

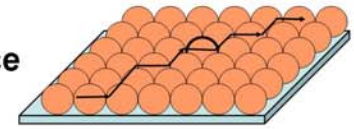
1. Understand the role of morphology on Metal - Insulator transition.
2. Explain hopping and logarithmic temperature dependences of granular insulators and metals.

Granular metals/insulators in different dimensions



Granular Metals characterized by two conductance's :

g_0 - grain conductance



g_T - tunneling conductance

$g_0 > g_T$ - granular limit

$g_0 \approx g_T$ - homogeneous limit

Different transport regimes:

Weak coupling between grains $g_T < g_c$

Strong coupling between grains $g_T > g_c$

g_c — critical conductance

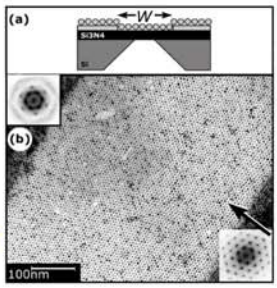
INSULATOR g_c METAL g_T

Metal – Insulator transition

Localized electrons : $g_T < g_c$

Problem of hopping transport In granular arrays is two fold:

1. origin of finite density of states near Fermi energy
2. mechanism of electron tunneling over long distances through array of grains

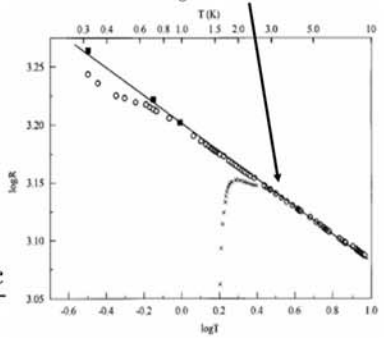


$$\sigma = \sigma_0 \exp\left(-(T_0/T)^{\beta}\right)$$

Delocalized electrons : $g_T > g_c$

$$R = R_0(1 + \alpha \ln T)$$

At relatively high temperatures logarithmic temperature dependence In all dimensions !



$$\frac{\delta\sigma}{\sigma_0} \sim \frac{1}{g_T} \ln \frac{g_T E_c}{T}$$

Future directions:

1. Study of *one-dimensional* granular arrays, full description of transport in quantum wires
2. Investigation of *hybrid* nanocrystals made of superconductor/ferromagnet components
3. Synthesis of novel superconducting nanocrystals in the 5-10nm size range

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